



## Lesson 1: Safety and Teacher Demo

**Key concepts:** Safety, simple drone physics, parts of a drone

**Objectives:** Through this lesson, cadets will gain knowledge of the parts of a drone and how they interact to make the drone fly with a teacher-led demonstration.

**Instructor Background:** What makes a drone fly?



### How to make a drone go up:

On an airplane, the propellers face forward and push the plane in the forward direction. On a drone, the propellers point upwards and push the drone in the upward direction. The spinning blades of a drone push air downward. As **Newton's third law** states, for every action, there is an equal and opposite reaction. As the drone propellers push air down, air pushes up on the propellers creating **lift**, the force that opposes gravity. The faster the speed of the propellers, the more lift is created and the faster the drone goes up.

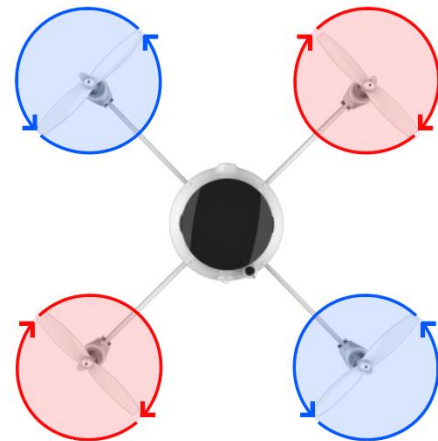
Summary:

- To make a drone go up, the force of lift needs to be greater than the force of gravity. If the force of lift is less than the force of gravity, the drone goes down. When the forces of lift and gravity are equal, the drone hovers in place.

### How to make a drone turn:

Your Circuit Scribe Drone has two sets of propellers rotating in opposite directions. In the image to the right, the top left and bottom right are spinning in the counterclockwise direction while the top right and bottom left are spinning in the clockwise direction. When the drone is stationary in the air, the propellers are all going at the same speed. (Remember, speed is a **scalar quantity**, meaning that each propeller moves at the same rate. Scalar quantities do not take into account the direction an object moves.)

One set of propellers has a negative angular momentum and the other set have a positive angular momentum. However, the net angular momentum at the drone body is zero.



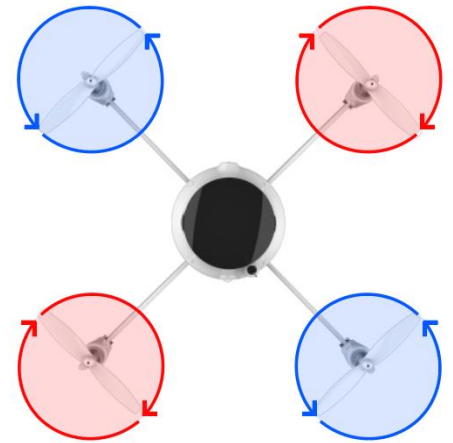
To make a drone turn in a certain direction, the net angular momentum at the drone body should not equal zero. This happens when one set of propellers spins faster while the other set spins slower by the same factor. By increasing the speed of one set at the same rate that the other set is decreased, the overall upwards force remains the same. This ensures that while the drone rotates, it does not move up or down in the air.

Summary:



- To rotate the drone clockwise, increase the speed of the motors going clockwise and decrease the speed of the motors going counterclockwise. This will make the angular momentum of the drone body point in the clockwise direction.
- To rotate the drone counterclockwise, decrease the speed of the motors going clockwise and increase the speed of the motors going counterclockwise. This will make the angular momentum of the drone body point in the counterclockwise direction.

As your Circuit Scribe Drone flies, its propellers move at a certain speed and spin in a certain direction. The image to the right demonstrates that the top left and bottom right propellers are spinning in the counterclockwise direction, while the top right and bottom left propellers are spinning in the clockwise direction. When the drone is stationary in the air, the propellers are all going at the same speed. For the drone to turn clockwise, the clockwise propellers must move at a faster speed than the counterclockwise set. For the drone to turn counterclockwise, the counterclockwise propellers must move at a faster speed than the counterclockwise set.



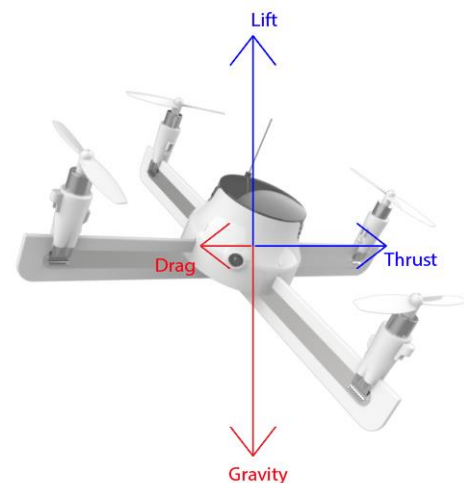
Summary:

- To rotate the drone clockwise, increase the speed of the motors going clockwise and decrease the speed of the motors going counterclockwise. To rotate the drone counterclockwise, increase the speed of the motors going counterclockwise and decrease the speed of the motors going clockwise.
- To keep the drone from moving upward or downward while you are rotating it, ensure that, as the speed of one set of propellers increases, the other set is decreased. This keeps the overall lift force the same, as the amount of air being pushed down by the propellers remains constant.

### **How to make a drone move horizontally:**

For a drone to move in any direction, it needs **thrust**, a forward force. Below is a drone's free body diagram, or a picture representing the forces on the drone, as it moves to the right. The blue arrows, thrust and lift, are the forces applied by the motors. The red arrows, drag and gravity, oppose the force created by the motors. In particular, gravity is a naturally-occurring force that points in the direction opposite to lift and drag is a force of friction that points in a direction opposite to thrust. The arrows in the free body diagram represent the net force in that direction as a result of all four motors. In reality, each motor applies  $\frac{1}{4}$  of the total thrust and lift.

Moving the drone in any direction is a balancing act. The total lift needs to remain the same as the weight of the drone to keep it at the same height. The total angular momentum needs to remain at zero so the drone doesn't rotate/the speed of all propellers need to remain the same so the drone doesn't rotate. For the drone to move in a horizontal direction, it needs a forward component of thrust from the propellers. This can be accomplished by reducing the speed





of two adjacent motors and increasing the speed of the other two motors by the same factor. For example, if you wish to move the drone to the right as pictured in the free body diagram above, the speed of the two motors on the left should be increased and the two motors on the right should be decreased.

## Drone Safety Review

In a classroom full of kids excited to learn about drones, a flying object with propellers going at 15,000 rotations per minute. can pose a danger. Review the full list of safety rules on page \_\_. Before turning on a drone in class, inform cadets of the dangers that come along with drone operation and the safety rules in place to prevent these dangers.

### Rules:

- Only fly drones in a designated flight zone.
- Always keep a flying drone in sight.
- Do not fly in adverse weather conditions, such as in high winds or reduced visibility.
- Do not handle the drone while propellers are moving.
- Keep drones off the floor where they can be stepped on.
- Do not touch the hot motors after flying a drone.
- Never fly over people.

## Attention Signal

An attention signal is an easy way to regain control of a noisy classroom and should be established at the beginning of flight school. Cadets should be instructed to land any flying drones, stop talking, and focus their attention on the instructor when signaled. Establishing an attention signal at the beginning of flight school sets the tone for the entire course. These signals inform cadets that although this is a fun learning experience, when the teacher is ready to give instructions, everyone needs to listen. An attention signal can be as easy as blowing a whistle. The whistle can be heard over the noise of a classroom and a swarm of drones and signals flyers to land their drones. . Other common attention signals include:

1. Teacher call: "Clap once if you can hear me," Cadet response: a clap.
2. Teacher call: "One, two, three, eyes on me," Cadet response: "One, two eyes on you".



## **Activity 1: Forming groups and going over safety procedures**

### **Materials:**

List of cadets

- Safety worksheet
- Role cards
- Folders for cadets (flight academy portfolio)

**Time:** 10 - 15 minutes

**Description:** In today's lesson, cadets will form the groups that they will be in for the rest of Flight Academy. It is up to you, the teacher, whether groups are assigned or created by the cadets. In their groups, cadets will learn about drone safety. Cadets will learn about their roles during Flight Academy.

**Plan Ahead:** If you choose to make the groups for Drone Academy, you should create the groups before class. Print out the role cards and prepare the folders for cadets. Each folder should have the safety worksheet and the printed rule agreement.

**Roles:** No roles are necessary for this activity, but role cards should be handed out in the folder for labeling.

**Safety:** Not applicable.

### **Step-by-step:**

1. Introduce the attention signal and give the attention signal a few test rounds.
2. Have cadets get into groups. If you have created the groups, announce the groups now. If the cadets get to make their own groups, instruct them to form into teams of 3. Use the attention signal.
3. Go over the roles and display the role cards to the cadets. Let cadets know they will be assigned roles in subsequent lessons and will have the opportunity to switch roles over the course of each lesson. Let students know they will be referred to as cadets while in Flight Academy.
4. Assign each group a number. Write this number down so it doesn't change over the course of flight academy.
5. Give cadets a chance to come up with a team name.
6. Pass out the Flight Academy logs, one to each person. Have cadets write their own name, group number, and the team name on their log.
7. With the cadets sitting with their groups, go over drone safety including the "Drone Safety and FAA Guidelines" (located in the overview). Cadets can follow along online. ([https://www.faa.gov/uas/recreational\\_fliers/](https://www.faa.gov/uas/recreational_fliers/)).
8. Have cadets sign the printed rule agreement in their Flight Academy logs.
9. Have cadets complete the "Drone Safety" worksheet in their groups.
10. Ask cadets to place all materials for the Flight Academy in their flight portfolio let cadets know that their Flight Academy log should be returned to the teacher at the end of each class.



## Activity 2: Teacher Demo

**Materials:** One Circuit Scribe Drone kit, a mobile phone, lesson one worksheet

**Time:** 15- 20 minutes

**Description:** In this activity, cadets will learn basic physics about how drones fly. A teacher will demonstrate a drone in class. Cadets will fill out a worksheet on the information they learned.

**Plan Ahead:** Set up a flying zone in the classroom. Charge a drone battery. Pass out lesson 1 handouts and the lesson 1 worksheet.

**Roles:** No roles are necessary for this lesson.

**Safety:** Not applicable.

### Step-by-step:

1. Pass out the “Parts of a Drone and Important Terms” handouts. Give cadets a few minutes to look over the handout.
2. One-by-one, take out the drone pieces, including the battery from the charging station, and inform the cadets of the name and purpose of each part. Once each part has been explained, assemble the drone in front of the cadets (using the PCB arms) so they will know how to put together their own drone when it’s time.
3. Pass out the “How a Drone Flies” handout.
4. Use the handout to teach cadets how drones take off, turn and move.
5. Review the safety procedures.
6. Have the class gather around the flying zone. Fly the drone up and down, left to right, and in a circle. Land the drone and put it away.
7. Pass out the “Lesson 1 Worksheet” for cadets to work on in their groups.
8. When the cadets are done with the worksheet, begin the discussion.
9. Remind cadets to return their Flight Academy logs with completed materials.

## Class Discussion

Offer the cadets a question and answer session after the activities. Once all of the cadets’ questions are answered, begin to ask the discussion questions.

- Why do drones have two propellers that spin clockwise and two that spin counterclockwise?
- What could you change on the drone that would make it fly higher?
- How does a drone fly?
- Would the drone fly in space?
- What do you think causes the motor to make so much noise?